SURVEY ON NUTRITION ASSISTANT APPLICATION

Abstract : A well balanced diet with an estimated nutrient intake is vital for infants and children which reduces the risks of deadly diseases namely cancer, diabetes, obesity and cardiovascular diseases. Unlike adults, infants require some assistance in their food intake. The survey provides valuable insights about the various advancements of IoT in the healthcare industry and the need for nutrition and dietary monitoring. A varied number of nutrition monitoring systems for the estimation and prediction of calories have been developed using various machine learning techniques and also with advanced deep learning based techniques. A comparative view of the previous works of researchers in the recent times has been provided.

Index Terms **– Nutrition Monitoring, Machine Learning, Neural networks, Deep Learning.**

I. INTRODUCTION

Systematic monitoring of the daily nutrient intake in infants and ensuring that there exists a balance is very important for the healthy growth of children. Most of the children in their budding age suffer undernutrition which is the main reason for infant child mortality and morbidity. Almost 90% of the children suffering from undernutrition are from the developing countries [1]. Fulfilling the balanced nutrition requirement of the children helps to reduce malnutrition and also reduces the threat of other diseases that are encountered due to lack of nutrition. The IoT is an enabling technology which consists of things connected in a network to communicate and share data. The life of the user becomes comfortable by adopting the various technologies based on IoT [2]. The Internet of Things helps in providing a probable solution to suit the varied demands of improving the healthcare systems and is also one among the main focus of major research works [3-5]. There is a great impact on the healthcare industry by IoT and it also improves the lives of millions of people all over the world enabling remote assistance. The IoT has the capability to safeguard the health of a patient but also helps the physicians to ensure care [6, 7]. An analysis was conducted in India on the various features that affect infant mortality rate in the Indian states [8].

A. Food Image Databases

A complete assortment of highly qualified food picture is essential to train a model for the classification of food and standardize the performance of predicting the massive food image databases like namely Food-101, UEC Food-256 and UEC Food-100. The present datasets associated with food images have varied aspects particularly the amount of food item groups, the overall number of images for a particular food class and conjointly the kind of culinary art [9, 10].

B. Image Based Food Recognition

a. Food image segmentation

Segmentation is the method of mouldering an image into an outsized variety of non-overlapping meaningful areas along with the similar attributes. When the complexity and difficulty are considered, the various segmentation algorithms have been successful in varied measures. The Clustering analysis algorithm is widely being incorporated in image segmentation applications, divides the datasets into different groups in accordance to a particular standard. The food images are analysed to extract the food items before the food classification [11-13].

b. Feature extraction

Feature extraction may be defined as a spatiality reduction technique in which the starting set of raw variables are reduced to additionally manageable features for processing, whereas still accurately and utterly describing the original dataset. The characteristics like shape, colour and texture can be utilized to identify the image [14]. The process of selecting the appropriate features is essential when a recognition model is built for recognizing the food images [15].

c. Food classification

Food classification strategies for image recognition are the machine learning based approach that consists of features and the deep learning approach. The Machine learning based approach consists of feature extraction and they are used to construct a prediction model based on various algorithms like Support Vector Machine (SVM), K Nearest Neighbours (KNN) and Bag of Features. In contrast, the emerging deep learning approach has a huge amount of connected layers which learns the various features, succeeded by a final layer which is responsible for classification. Deep Learning based approaches have become more popular and effective.

d. Food volume estimation and nutrient analysis

After the food items have been identified, the nutrient content has to be analysed. The volume estimation is done on the segmented food and the corresponding nutrient value is calculated using respective tables namely USDA Food Composition Database. The volume can either be underestimated or overestimated due to external factors like lighting conditions, blurred pictures, and no background [16-18]. There are only few strategies that perform food calorie and volume estimation, as presently the important focus ofthis domain still lies in the focus of food classification [19].

II. REVIEW OF LITERATURE

A. Prabha et al., [20] proposed a Smart Log system that performs automated nutrition monitoring and meal prediction. The smart sensor board consisting of Piezo Electric sensors is used for nutrition quantification. The nutrient data acquisition is done using Optical Character Recognition and by linking open source Application Program Interfaces (APIs) through barcodes. The meal prediction is done by collecting nutritional value of the leftover food along with the user's feedback on the type of food that is desired. The SR8 database available through the US Department of Agriculture website is also analysed using their API which provides a food report of associated nutrient values for a particular food item and a nutrient report which gives an extensive list of food and their nutrient values for a selected amount of nutrients. The results have been analysed by creating an Attribute-Relation File Format which inputs the Waikato Environment for Knowledge Analysis (WEKA) tool which builds a better prediction model and is observed that the Bayesian classifiers provided better results. The open dataset consisted of multiple redundant logs and psychological monitoring mechanisms have not been incorporated which in turn leads to lack of accurate prediction.

B. Manal et al., [21] proposed a machine learning based pipelined approach for predicting the calories from food images. The system takes an image of the food item and passes it through Mathworks Image Processing which extracts the raw features and improves the quality. The image is passed through a compression phase which helps to reduce the number of features using the Principal Component Analysis (PCA) method and scale the subsequent learning phases. The food type classification is done by inputting the compressed image to the classifier. The food size prediction is done by passing the compressed image to a regressor. Calories are predicted by passing the compressed image and predicted values to another regressor. This is based on supervised learning model. The dataset is limited to a small category and the image cannot be diversified.

C. Kohila et al., [22] proposed a calorific value prediction mechanism using image processing and machine learning. The image of the food is transmitted through a mobile device and it initially undergoes segmentation with Fuzzy C-means Clustering Segmentation which fixes the cluster centre based on the group data unlike the K-means Clustering which can be erroneous if the cluster centre is not defined properly by the user. The mathematical morphology is utilized as a tool for extracting the image components and the region shape description such as erosion, dilation, opening and closing. Feature extraction is performed to retrieve interesting parts of the image and then calorie measurement is done. It has limited scalability and diversely mixed food images have not been considered.

D. Sangita et al., [23] proposed a nutritional status investigation system based on machine learning. A logical regression model was considered for the major four variables namely BMI (Body Mass Index), HAZ (Height for Age Z score, also known as stunting), WHZ (Weight for Age Z score, also known as wasting) and WAZ (Weight for Age Z score, also known as underweight) individually. The study predicts the nutrition state of the child in two phases. Phase I pre-processes the dataset using SMOTE Resampling method. Feature extraction is done using machine learning techniques with Entropy based Gain Ratio concept. Phase II uses Nominal logistic regression using iterative reweight least squares algorithm which predicts the characteristic features. The dataset is based on a very specific geographical area and over a particular period of time and it also considers only the basic features.

E. Oscar et al., [24] proposed a menu-match: restaurant-specific food logging from images. An image recognition framework based on the bag of visual words approach which extracts the base features from the images and then encoded with locality-constrained linear coding (LLC). The extracted features are pooled using max-pooling in a rotation-invariant pooling scheme. A regression based method estimates the calories and along with feature representation mapped the feature space to calories using Support Vector Regression. The approach is limited for discrete serving sizes and custom menu and is also dependent on the GPSS of food consumption. The system lacks user customization and requires cost-sensitive learning to directly minimize calorie estimation errors during the training.

F. Kiran et al., [25] proposed a method for measuring the calories and nutrition from food images using machine learning techniques. The images got from the mobile device are pre-processed followed by the segmentation step to extract the colour and texture features through K Means clustering. The extracted options are used for food classification using Support Vector Machine (SVM). The food portion volume measurement is done by superimposing a grid of squares onto the image segment which matches the irregular shape of the food images easily. The calorie measurement is done based on the food mass and nutritional tables. The system has limited cuisine varieties mixed food images have not been considered.

G. Prabha et al., [26] proposed a Smart Log system based on deep learning for automated nutrition monitoring system in IoT. The proposed system is composed of a smart sensor board along with an application. Automatic Nutrition Quantification is the first step which collects the quantity of nutrient values along with the timestamp and transmits it to the cloud. The nutrient data acquisition is done using Optical Character Recognition in which the on-phone camera captures the FDA-mandated Nutritional Facts Label and the other method is by linking open source Application Program Interfaces (APIs) through barcodes. The meal prediction is done by collecting nutritional value of the leftover food along with the user's feedback on the purpose of the meal. Food Classification is done through an algorithm which is built on a Bayesian or Belief Network (BN) with constraint based method. A multi-layer perceptron neural network is constructed using Stochastic Gradient Descent and hill-climbing search is used for food classification. The system is designed only for the children and the dataset contained multiple redundant logs.

H. Parisa et al., [27] proposed a method for food calorie measurement using deep learning neural network. The system uses food images and the features are extracted using Graph Cut Segmentation. A pre-trained model file is generated with the help of Convolutional Neural Network (CNN). It is loaded into the application and tested to perform image recognition process. The stochastic gradient descent algorithm is used to get an improvement in the cost. The calorie measurement is done by two approaches namely finger based calorie measurement and calorie measurement using distance estimation. The system lacked analysing mixed food portion and only limited samples were considered.

I. Yanchao et al., [28] proposed a calorie estimation model based on deep learning approach which increases the detection accuracy and reduces the error of volume estimation. The image acquisition is done by obtaining the food image using a smartphone. The object detection is done by using Faster Region based Convolutional Neural Networks (Faster R-CNN), which includes Region Proposal Network (RPN) and an Object Detection Network. GrabCut, an image based segmentation algorithm which depends on optimization by graph cuts is used for image segmentation. Volume Estimation requires calculation of side and top views scaling factor using equations based on the shape types. Finally, calorie estimation is obtained by using the volume and density value of the food mapped using ECUSTFD dataset. The limitation in this system is that it has 20% and more mean error for the discrepancy in the estimated result when compared with the actual values.

J. Bruno et al., [29] proposed an automated food recognition system that provides dietary intervention based on computer vision and machine learning. The unique feature of the system relies in the realization of real-time energy balance with the help of network simulation. Food recognition deals with the challenges in image segmentation, classification and the volume-nutrient estimation. Food segmentation is done on the food image using Otsu's segmentation. Feature extraction is done using Local Binary Patterns (LBP), colour, texture and Scale-Invariant Feature Transform (SFIT). Classification is done using SVM, Bag of Features and K Nearest Neighbours. Weight estimation is done by mapping the nutritional facts from the USDA dataset and then followed by metabolic network modelling. The intervention module provides insightful information regarding the nutrients, eating patterns and alerts for the same are provided. The performance has to be improved and deep learning techniques with wearables could have been incorporated.

K. Chang et al., [30] proposed a food image recognition for computer aided dietary assessment based on deep learning techniques. The proposed approach utilized two real-world food image datasets namely (UEC – 256 and Food – 101). The food image recognition is done by a new Convolutional Neural Network (CNN) method based on supervised learning algorithms. The CNN consisted of 3 convolutional layers, 2 sub sampling layers and a fully connected layer. The model was trained for a nonstop period of 2 to 3 days using a server with Nvidia K40 GPU. After the training, the model classified the image in less than a minute. The proposed system lacked real-world data and the accuracy of the measurements have to be improve.

L. Yoke et al., [31] proposed an approach to measure the food nutrition using pocket-size Near Infrared Sensor. A SCiO scanner was used to acquire the nutritional facts using the NIR spectra. The reflected spectrum is uploaded to the SCiO web server through the SCiO application on a smart phone. Based on the varied absorption level of the wavelength, the distinction between the foods is made. The system used 14 off-the-shelf drinks as the input data. The model is trained by correlating features of NIR spectra with energy and carbohydrate contents of different drinks. Finally, the accuracy of prediction model is assessed. The Partial Least Square (PLS) regression and Support Vector Regression (SVR) were used and the analysis proved that SVR with RBF (Radial Basis Function) performed better.

M. Bahman et al., [32] proposed a smart nutrition monitoring system using heterogeneous Internet of Things Platform. The proposed architecture is based on emerging Fog computing concepts in which pre-processing and lightweight analytics are done by data collection points after which the data is sent to the cloud. The data collection points (i.e., kiosks capture the food image from different angles and pass them to the cloud server which generates a 3D model of the food. The Smart Nutrition Monitoring Engine has 4 components namely Collection Management, Data Analytics, Data store and Visualization. The Collection Management is responsible to upload the data to the cloud server and also for information storage. The Data Analytics component does the statistical analysis and machine learning activities in the system. The data store stores the raw data as well as the processed data. The visualisation module displays charts portraying the food consumption. As a future work, the author aims to adopt new sensors to the system and also a fault-tolerant system thereby increasing the accuracy.

N. Niloofar et al., [33] proposed a mobile platform for nutrition monitoring from spoken data called Speech-to-Nutrient-Information (S2NI). The system monitors the food intake using natural language processing through the speech-to-text mobile application. The speech recognition module inputs a stream of sampled speech data and a sequence of words is the required output which is done by sampling, end pointing, feature extraction and template matching. The Natural Language Processing (NLP) module is based on machine learning techniques and this work used Parts of Speech (PoS) tagging which is a supervised machine learning problem. The string matching module uses two methods namely exact matching and approximate matching to match the detected words with the nutrition database. The USDA national database is used. The performance of the various models is analysed at each level. The system achieves 80% accuracy in computing the calorie estimation.

O. Akpa et al., [34] proposed a smartphone-based automatic food weight and calorie estimation method using ordinary chopsticks as a reference for measurement. The images are collected using a mobile application using the built-in camera and are stored. The food weight is computed and the calorie estimation is done by relying on the Nutritional Fact Database (NFD) using a restaurant database as a ground truth data to determine the accuracy of the proposed work. The proposed system portrayed an average relative error for measuring the weight is 6.65% and 6.70% is the relative error for calorie estimation.

Figure 1 displays the variety of techniques that are can be used to monitor the food intake along with their advantages and limitations [35].

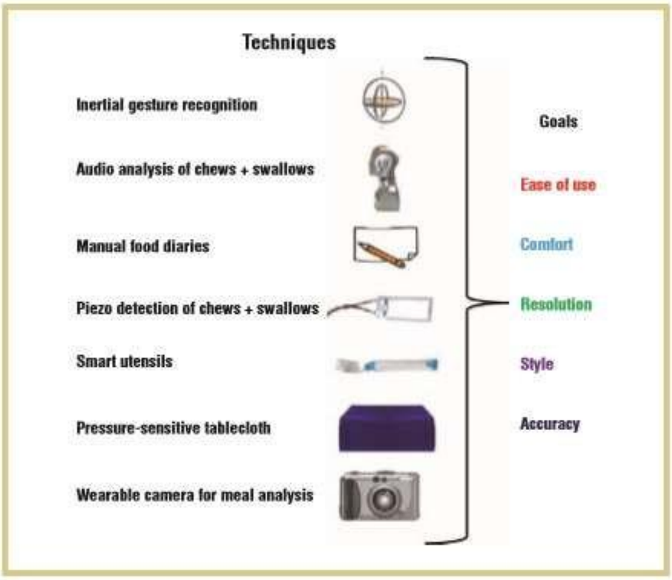

Fig. 1 Various food intake monitoring techniques and their advantages

III. COMPARISON OF RESEARCH WORKS

Table 1: Comparison of Research Works

Title	Approach	Advantage	Limitation
Prabha et al., [20]	Machine learning based prediction using OCR and APIs	Automated nutrition monitoring and meal prediction	Psychological monitoring mechanism is not incorporated
Manal et al., [21]	Machine learning based pipelined approach using PCA	The pipelined approach is very effective when compared to the baseline	The dataset is limited to a small category and lacks realistic scenario
Kohila et al., [22]	Machine learning based Fuzzy c-means clustering for segmentation and Morphological operation for extracting image components.	The approach has efficient feature extraction mechanism	Lacks mobility and there is a deviation in calorific value between the observed and calculated values
Sangita et al., [23]	Machine learning with Entropy based Gain Ratio concept and Nominal logistic regression using iterative reweight least squares algorithm	Explored the likelihood of using artificial intelligence in recognizing the possible correlates of malnutrition.	The data is limited to a particular time, context and only limited features are considered.

Oscar et al., [24]	Machine learning based SVM classifier and LLC	Automated computer vision system for logging food and robust calorie estimation	It lacks user customization and is GPSS dependent
Kiran et al., [25]	Machine learning based K Means clustering and SVM	IMg2 calories app that determines the calorie intake and estimation.	Has limited cuisine varieties and mixed food images have not been considered.
Prabha et al., [26]	Deep Learning based novel 5-layer neural network perceptron and a prediction algorithm based on Bayesian network	The prediction accuracy of Smart-Log is 98.6%.	Psychological monitoring mechanism is not incorporated
Parisa et al., [27]	Deep Learning based Convolutional neural networks with virtualization	The accuracy for single food portions is 99%	The database is limited and mixed food portions have not been considered.
Yoke et al., [31]	SCiO – NIR sensor and regression techniques	Liquid food nutrients were predicted	The nutrients were estimated only through percentages
Niloofar et al., [33]	Natural Language Processing and Text Mining	The accuracy is 80.6%	The experiment was only laboratory tested

IV. CONCLUSION

The Internet of Things (IoT) is a booming technology that spans across various domains and its incorporation with healthcare is increasing day to day. This survey presents a comparative view on the research works in the nutrition monitoring, calorie estimation and dietary systems. The machine learning techniques are being replaced by the deep learning techniques that outperforms the traditional methodologies. There is also an increase in the integration of wearable sensors along with smartphone through mobile technologies which will be a revolution in food monitoring systems which helps in disease prediction, risk analysis and prevention.